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On the early breakdown in film superheating

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Maximum attainable metastable superheat value (T_m) of the low boiling organic liquids, as determined by Sinha *et al* (1961) and Basu *et al* (1969) in their film superheating method was found to be about 10–25% lower than the value reported by other workers for the corresponding liquids (Wakeshima *et al* 1958, Skripov *et al* 1964, Skripov 1974, Smitsyn *et al* 1967, Blander *et al* 1971, Eberhart *et al* 1975) Porteus *et al* (1975) and Blander *et al* (1975) pointed out that these lower superheat values might have been caused by heterogeneous rather than homogeneous nucleation as Sinha and his co-workers superheated liquids on solid glass surfaces.

It is true that the liquids were heated on glass surfaces, with the aim that the film remains in the superheated state for a reasonably long time (approximately 2–3 mins.), offering the scope of studying the liquid properties (e.g. the effect of electric field, ionizing radiation, etc.) in the superheated condition The authors were very much concerned about heterogeneous nucleation and therefore took extreme care in designing their experiments to ensure that there was no active vapour pockets on the glass surface which might act as a source of heterogeneous nucleation As a precautionary measure the heater bulb was annealed to a temperature of 450°C for 48 hours in a temperature controlled electric oven for removing surface scratches. Before performing a particular set of experiment the heater bulb was kept immersed in a concentrated solution of sulphuric acid saturated with potassium dichromate for about 24 hours. to remove any greasy substance present on the surface It was then thoroughly rinsed with steady flow of distilled water and was introduced into a degassing chamber, where it was subjected to 10^{-3} m.m. of Hg., to remove any gas, water or oil vapor absorbed in the surface layer of the bulb Also it is worth mentioning here that the liquid superheat in heterogeneous nucleation is found to be much lower (Basu 1978) than that obtained by the film superheating method of Sinha and Jalaluddin (1961).

A possible explanation of the early breakdown in the film superheating method may be arrived at, if we consider the mean lifetime or as it is technically called the "time of expectation" (τ) of the superheated layer. Wismer[1] (1922)

observed that τ has some influence on the limiting superheat value. The appearance of spontaneous embryo in the metastable phase is a random event. At a sufficient purity of the system and constant external conditions, nucleation is characterized by a definite and reproducible time of expection τ of the embryo. If the number of observations is large, the times of expectation can be represented by Poisson distribution. Sinitsyn *et al* (1968) measured the life times of superheated liquids at different degrees of superheating in a Bubble Chamber. Figure 1 shows some of the results for *n*-Pentane (Skripov 1974). It is found that upto an initial period of 10 secs. the liquid can stand high superheat which

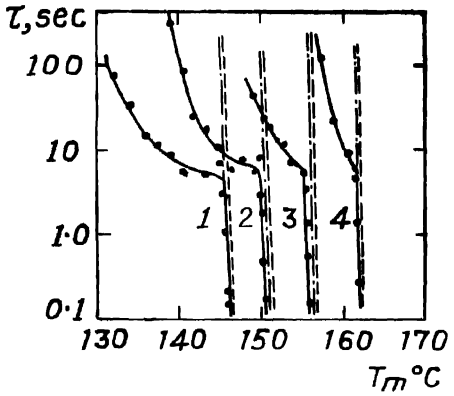

Figure 1. Temperature dependence of the average lifetime of superheated *n*-pentane along the isobar

1. $p =$ 1 bar; $T_s =$ 36·1 °C
2. $p =$ = 4.9 bar, $T_s =$ 92·0 °C
3. $p =$ 8·8 bar, $T_s =$ 119·0 °C
4. $p =$ 12·8 bar, $T_s =$ 138·5 °C

approximates Döring-Volmer (1939) theory and Kagan (1960) theory, but above 10 secs. and superheat value falls rapidly and at 100 secs. the value is approximately 130°C which is very near to the value (132°C) reported by Sinha and Jalaluddin (1961) In the film superheating experiment of Sinha *et al* the temperature of the heating surface was increased at the steps of not more than 2°C and kept at that temperature for about 2 mins. to attain the steady state. This 2 mins. time may be considered as the time of expectation (τ) and the early breakdown of the superheated layer may be explained. Table 1 shows the experimental and predicted values of superheat limit of *n*-pentane at the pressure of 1 bar.

Table 1. Maximum superheat value of n-pentane at 1 bar
T_{cr} = 196.6 °C P_{cr} = 33.8 bar
T_{sat} = 36.1 °C at 1 bar

Author	System	T_m°C
Experimental values		
Basu (1978)	superheating on vertical copper surface of r.m.s. roughness = 10 μ in.	60·5
Sinha and Jalaluddin (1961)	Film superheating on smooth glass surface	132·0
Skripov (1974)	Bubble Chamber	146·1
Wakeshima and Takata (1959)	Droplet superheating	146·0
Skripov and Kukushkin (1961)	Droplet superheating	145·0
Blander et al (1971)	Droplet superheating	147·8
Predicted values		
Döring-Volmer (1939)	$J = 1.10^2$ cm^{-3} sec^{-1}	146·1
Kagan (1960)	$J = 1{\cdot}10^2$ cm^{-3} sec^{-1}	146·0

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